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03MAR03 E788822-10 D00180
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1.	Your reference	ABC/21481
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3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	BT (IP) Limited 1 Astra Centre Edinburgh Way Harlow Essex CM20 2BN United Kingdom
	Patents ADP number *(if you know it)*	764533001
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	GAS VALVE WITH PROPORTIONAL OUTPUT
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	A A Thornton & Co 235 High Holborn London WC1V 7LE
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Request for preliminary examination and search *(Patents Form 9/77)*	1
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GAS VALVE WITH PROPORTIONAL OUTPUT

The present invention relates to the control of low pressure combustible gas flow.

Indexing mechanisms that amplify piezo electric actuator motion, as disclosed in UK Patent Application GB0030263.8 and GB0011350.3 can be used to provide gradual opening of a face seal, but the cost of such systems is prohibitive when compared to a manual solution.

Poppet valves, where the seal is pressed onto an orifice and lifted off are commonly used in such applications, but proportional control of such devices is hampered by the nature of their opening. In a situation where the incoming gas pressure is resisted by a spring and the actuator pulls the spring off, the forces required are increased for the actuator by the spring's sealing force and additionally by its spring rate. When the valve is closed by the gas pressure the pressure differential collapses as the seal begins to open, and the actuator then overshoots. Solutions such as motors with worm drives can solve this problem, but at a cost that is prohibitive.

For cost reasons it is desirable to make use of simple parts with low energy consumption and this has caused piezo-electric actuators to be considered. However, such actuators encounter problems where the movement required is large. When dealing with gas valves, the movement is determined by the diameter of the inlet orifice. Smoot flow is obtained only when the seal is a minimum of 25% of the diameter above the orifice, as shown in Figure 1. This is because the area of a cylinder Diameter D and 25% of D high is equivalent to the area of the hole D, so the opening does not constitute a restriction.

Gas control valves are required to have a pressure drop of around 1 millibar when passing their maximum flow rate, although this varies slightly with different

specifications. In order to achieve such a low pressure drop it is necessary for the orifice to be roughly the same size as the incoming pipe. In most cooker installations the pipe has an internal diameter of 4mm, so the valve must lift at least 1 mm clear of the orifice, and preferably more. This amount of movement can only be achieved from a piezo-ceramic bender, not a stack, but only a limited range of designs offer such a movement at a reasonable cost.

Another factor is that the force available from a piezo-electric bender reduces linearly with the displacement, as shown in Figure 2. In order to maintain a useable level of force the assembly must work within 50% of the force and 50% of the unloaded deflection, as shown by the shaded box of Figure 2.

From the above information it can be seen that working with a bottom pressure system is unattractive, because the closure spring will double the work needed from the actuator, thus reducing by half the movement which is already close to the practical limits. Achieving the level of movement from the bender will require a system of relatively low stiffness. If the system is of low stiffness the process of opening against the gas pressure must resist the impulse caused by the collapse as the valve opens. If the actuator is flexible enough to give the motion required it tends to pull off the orifice and enter into a non-controlled oscillation that makes it impossible to accurately regulate the gas flow.

It is desirable to have a means of opening top pressure valves that prevents the unregulated oscillation whilst also permitting the full range of actuator motion to be used.

The present invention provides a valve for controlling fluid flow comprising a body provided with a fluid passageway having an inlet and an outlet, a valve member for inhibiting fluid flow through the passageway, and means for moving the valve member so as to provide for controlled flow of fluid from the

inlet to the outlet, wherein the valve member is in the form of a blade which is pivotable abut an axis remote from the passageway.

Preferably , the blade is formed to provide the desired force/displacement characteristics.

In a preferred embodiment, the means for moving the valve member is a piezo-electric actuator. Also, the valve may be provided with a plurality of inputs each provided with its own valve member. The characteristics of the valve members need not be the same in this case, but preferably a single actuator is used to operate the two valve members.

Further, a plurality of valves can be located side by side in a valve assembly which permits the assembly to be constructed from a number of layers.

In order that the present invention be more readily understood, an embodiment will now be described by way of example with reference to the accompanying drawings, in which:-

Fig 1 shows a diagram to explain the basic principles behind the present invention;

Fig 2 shows a further diagram to explain the basic principles behind the present invention;

Figs 3a to 3c show plan views of three different shapes of valve member useful with the present invention;

Fig 4 shows a diagrammatic side view of a part of a valve according to an embodiment of the present invention;

Fig 5 shows a modification of a part of the valve shown in Fig 4;

Fig 6 shows a detailed modification to the arrangement shown in Fig 5;

Fig 7 shows a top plan view of an array of valve members which can be used with the present invention; and

Fig 8 shows a perspective view of a complete valve assembly of a plurality of valves, each as represented by Fig 4.

According to the present invention there is provided a sealing system comprising an orifice and a valve member in the form of a thin blade of suitable dimensions and finish to form a gas-tight seal when top pressure of 20mBar is applied. The blade is preferably of metal. A number of blade shapes are suited to this application. A simple cantilever, a constant stress beam or a convolute that changes its stiffness geometrically as it opens are examples of such a blade. These fundamental beam shapes are shown in Figure 3 by way of illustration only.

The shapes of Figure 3 can be modified to have increasing or decreasing stiffness by the introduction of cutouts and other features.

Consider now the circumstance of the valve in the closed state, as shown in Figure 4, being a section through the valve, with no top. The arrows (20) signify the gas pressure. There is provided a bypass blade (40), a main flow blade (50) and a lifting member (60). The blades are located on the top surface (101) of the valve body (100) and the rear edges (41,51) are fixed to the body in some convenient manner eg by clamping, welding or bonding. The lifting member (60) is connected to a suitable piezo-electric actuator, but can equally well be connected to a magneto-strictive, electro-strictive or other active material than can be formed into a bender configuration. For low speed operation the mechanism may also be operated by a thermal bimetal.

The bypass blade (40) covers a bypass channel (70) that permits a restricted amount of gas to flow to the outlet of the valve (90), giving a controlled low-level flame suitable for pilot lights and simmer functions. The main flow blade (50) covers a main channel (80) that provides the full flow characteristic of the valve.

The force required to lift the blade from the sealed condition is defined by the equation:

F=S1+(Sxd)+(PxA)

Where

S1 is the initial compression applied by the seal blade;
S is the spring rate of the seal blade;
d is the distance needed to overcome any compliance in the seal;
P is the gas pressure difference between the valve and the outlet;
A is the area of the orifice being opened.

The same equation applies throughout the opening action. The valve lifter (60) has two steps on it such that the pilot port is opened first. The valve blades are made from thin material, typically 50 micron thick stainless steel, so the initial pre-load is in the order of 0.02N. The pressure exerted by the gas at 50mB operating temperature (PxA) is about 0.01N, and the distance to open is around 20 microns. Such a system requires just 0.05N to open it, and after the initial seal is broken the later seal is working with pressure differentials of just 10-15mBar, making it easier still to open.

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The phenomenon of uncontrolled oscillation is reduced by having sufficient stiffness in a simple cantilever, but preferably the blade is of such a form as to rapidly increase in stiffness as the orifice is opened. The deflection of a beam is determined by the equation:

$$d=wl^3/3EI$$

Where d is the deflection
W is the load
I is the length of the cantilever

E is the Young's Modulus of the material

I is the second moment of inertial of the section

For a simple beam the second moment of inertia is defined by

$I=bd^3/12$

Where b is the width

d is the beam thickness

If the width of the beam changes as a geometric progression the relative deflection will change as a linear inverse of this value. In the concept shown in Figure 3c of the part becomes increasingly stiff to move. In Figure 5 the position of the orifice (80) is shown relative to the beam shape. When the operating pressure drop is higher it may be desirable to increase the rate of stiffness change, and to do this the value d can be changed, because this is a cubic function. This is achieved by the introduction of an auxiliary blade (55) that is shown in Figure 5 and which is mounted along its edge 56. The orifice is firstly uncovered by the flexible blade and, as the pressure differential collapses, the oscillation is damped by the stiffer component.

It has been found advantageous when using the construction as shown in Fig 5 to modify the overall construction so that the orifice 80 is provided with a ~~resilient sealing surface such as would be present with an O-ring seal 81. this is~~ shown in detail in Fig 6.

Further, the flexible blade is loosely mounted at its mounting edge 82 so as to permit limited vertical movement which allows the blade to seal against the O-ring. The auxiliary blade 55 is arranged to make contact with the

flexible blade within the area of the orifice. Preferably, this is effectively point contact at the orifice. As with the earlier embodiments, the shapes of the flexible blade and the auxiliary blade 55 can be chosen to provide the desired valve characteristics.

The nature of the valve function is conveniently suited to the fabrication of the components in layers, permitting the replication of the basic construction as a multiple-output system. Figure 7 shows an array of 7 valve blades formed from a single sheet of material. The array can be any suitable multiple, seven being sufficient for four hobs, a grill and two ovens.

The use of a piezo electric bender actuator permits the actuators to be made as a single part or, if preferred, a multiplicity of single acting devices. Figure 8 shows a complete valve assembly having its actuators formed as a single array.

The arrangements shown in Fig 7 and 8 can be modified to utilise the construction described in relation to Fig 6 as the basic arrangement shown in Fig 4.

Through the above and similar constructions can be achieved a proportional electronic valve that uses low-force, high movement actuators to work against a top pressure in the region 20-200mBar with the control of the critical opening and restriction zones to prevent sudden opening and thus uncontrolled fluctuation in flow.

CLAIMS:

1. A valve for controlling fluid flow comprising a body provided with a fluid passageway having an inlet and an outlet, a valve member for inhibiting fluid flow through the passageway, and means for moving the valve member so as to provide for controlled flow of fluid from the inlet to the outlet, wherein the valve member is in the form of a blade which is pivotable about an axis remote from the passageway.

2. A valve according to claim 1, wherein the blade is in the form of a flexible plate having a free end which is arranged to be lifted from the body in order to progressively open the outlet of the passageway.

3. A valve according to claim 2, wherein the plate is shaped so as to provide a desired stiffness as it is lifted to open the outlet.

4. A valve according to claim 2 or 3, wherein the plate is loosely mounted at one end so as to provide a limited amount of movement in the direction of lifting.

5. A valve according to claim 4, wherein an auxiliary member is located over the flexible blade and contacts the blade within the confines of the periphery of the outlet.

6. A valve according to claim 4 or 5, wherein a sealing member is provided around the periphery of the outlet.

ABSTRACT

A valve for controlling fluid flow comprises a body provided with a fluid passageway having an inlet and an outlet, a valve member for inhibiting fluid flow through the passageway, and means for moving the valve member so as to provide for controlled flow of fluid from the inlet to the outlet, wherein the valve member is in the form of a blade which is pivotable about an axis remote from the passageway.

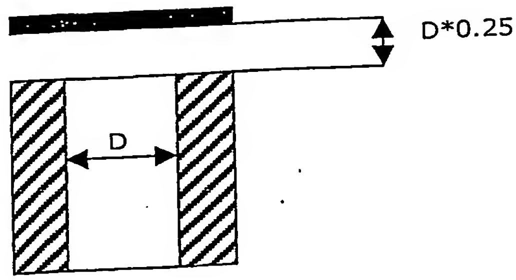


FIG. 1

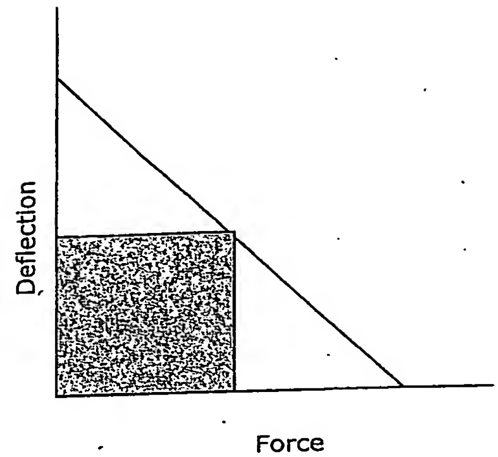


FIG. 2

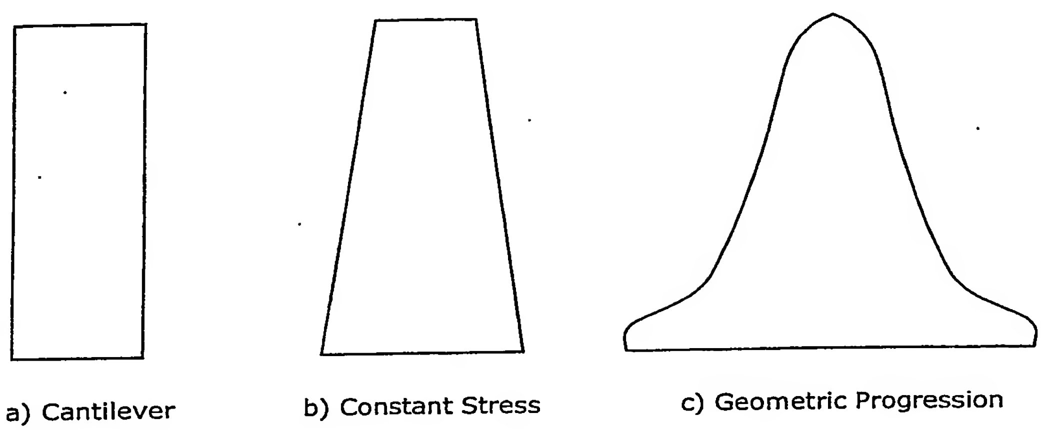


Figure 3

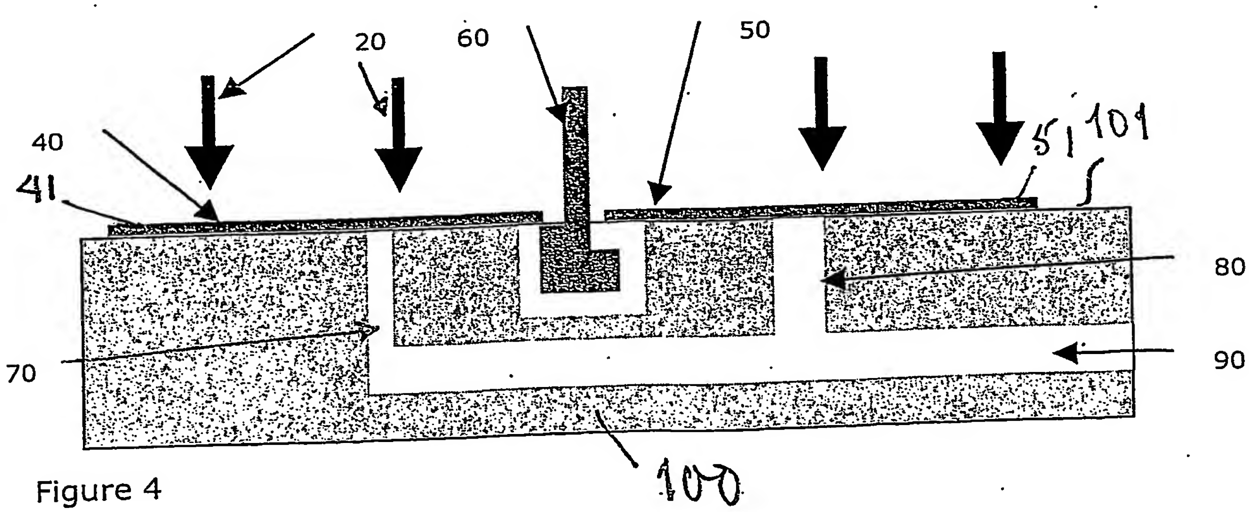
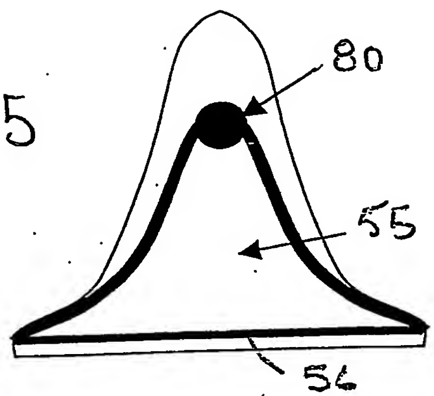


Figure 4

FIG. 5



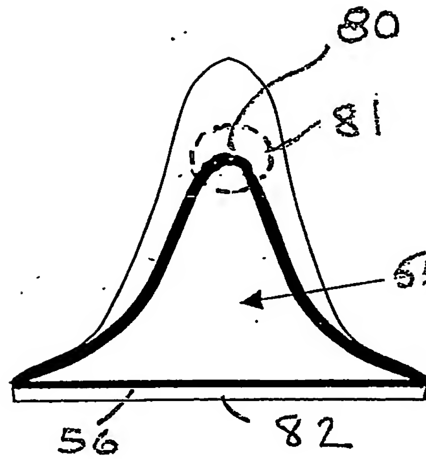


FIG. 6

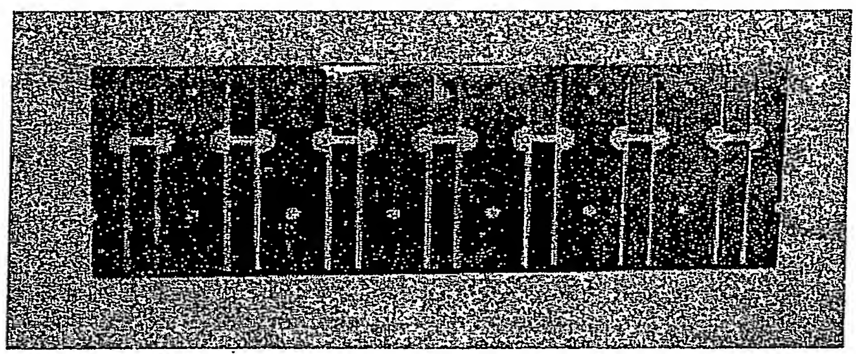


Figure 7

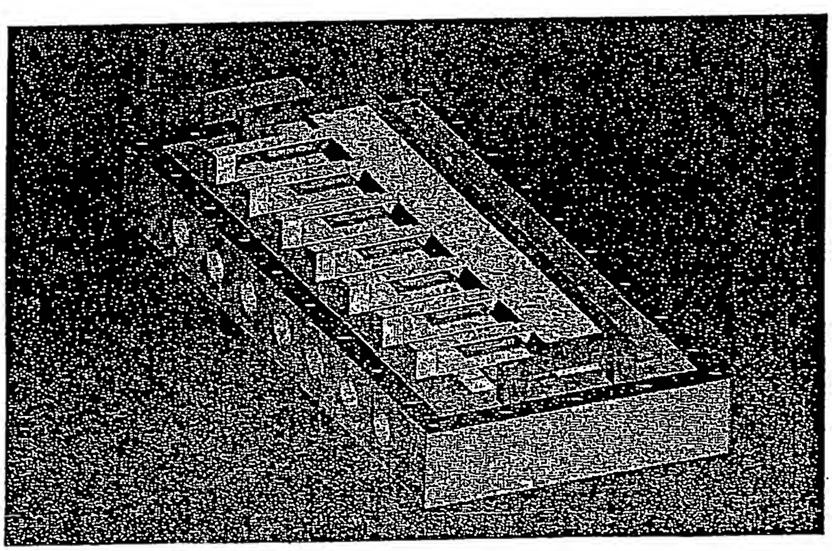


FIG. 8